SHIP PRODUCTION COMMITTEE
FACILITIES AND ENVIRONMENTAL EFFECTS
SURFACE PREPARATION AND COATINGS
DESIGN/PRODUCTION INTEGRATION
HUMAN RESOURCE INNOVATION
MARINE INDUSTRY STANDARDS
WELDING
INDUSTRIAL ENGINEERING
EDUCATION AND TRAINING

August 1988
NSRP 0298

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

1988 Ship Production Symposium

Paper No. 1:
The Use of Computers in Advancing Group Technology

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
AUG 1988	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
The National Shipbuilding Research Program: 1988 Ship Production Symposium Paper No. 1: The Use of Computers in Advancing Group Technology	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center CD Code 2230 - Design Integration Tools Building 192 Room 128 9500 MacArthur Blvd Bethesda, MD 20817-5700**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

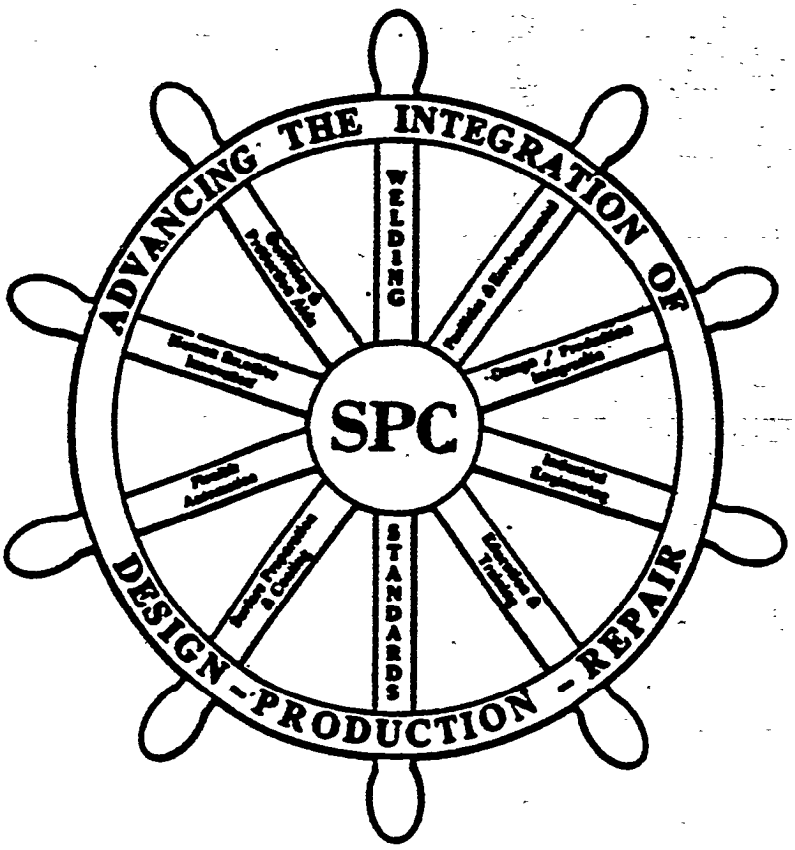
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**12**	

DISCLAIMER

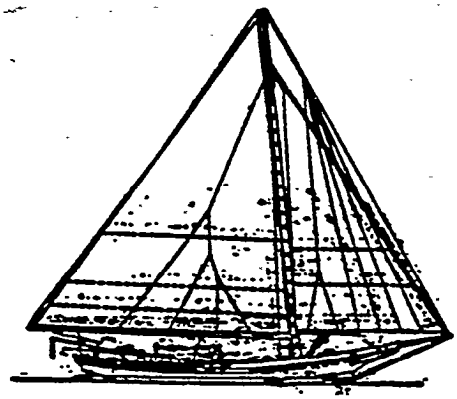
These reports were prepared as an account of government-sponsored work. Neither the United States, nor the United States Navy, nor any person acting on behalf of the United States Navy (A) makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness or usefulness of the information contained in this report/ manual, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or (B) assumes any liabilities with respect to the use of or for damages resulting from the use of any information, apparatus, method, or process disclosed in the report. As used in the above, “Persons acting on behalf of the United States Navy” includes any employee, contractor, or subcontractor to the contractor of the United States Navy to the extent that such employee, contractor, or subcontractor to the contractor prepares, handles, or distributes, or provides access to any information pursuant to his employment or contract or subcontract to the contractor with the United States Navy. ANY POSSIBLE IMPLIED WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR PURPOSE ARE SPECIFICALLY DISCLAIMED.

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM
1988 SHIP PRODUCTION SYMPOSIUM

0298



August 24-26, 1988
Edgewater Inn
Seattle, Washington



SPONSORED BY THE SHIP PRODUCTION COMMITTEE
AND HOSTED BY THE CHESAPEAKE SECTION OF
THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS
601 Pavonia Avenue, Jersey City, NJ 07306
paper presented at the NSRP 1988 Ship production Symposium.
Edgewater Inn, seattle. Washington. August 24-26 1988

The Use of Computers in Advancing Group Technology. No.1

Eric W. Stewart, Visitor, MDC Limited, Sunderland, Tyne and Wear, England

ABSTRACT

When introducing product oriented work breakdown techniques as the means of defining work within a shipyard, it is worthwhile considering the use of cmputers and how they may be utilised to improve the success of this task. This document addresses experiences gained and reflects on the systems in place in some of the shipyards within the United Kingdom.

INTRODUCITON

Modern and effective shipbuilding requires close control of material and labour at each stage of the process that begins at pre-contract specification snd continues through commnissioning such a high degree of control and the ready access to information that is required to meet that objective can be achieved by the introduction of an integrated computer based solution.

The computer industry has attempted over the years to provide a material and labour control solution for manufacturing based industries and some success has been achieved where the design, material procurement and manufacturing schedule are stable and the product well defined. This environment does not prevail however in shipbuilding and a different style of computing system must be made available to address project based manufacturing.

The initial design of a complex product such as a ship is commonly undertaken by using a system by system approach. This ensures that the final product will perform to specification. Production, which traditionally followed the same system oriented approach, now utilises a product oriented work breakdown structure which crosses these traditional boundaries. This product oriented organisation of work is required in order to reduce time scales, constrain costs and utilise a work force more effectively.

This reorganisation of the production process does not fundamentslly change the nature of the continuing design process which is characterised by continual iteration and refinement. In industries where the design process my be completed before procurement and prcduction commence this is of little consequence. In present day shipbuilding however, time and cost Constraints necessitate the overlapping of these processes. This has a major effect on the nature of any system which can successfully control the entire process, in that early estimates of material required will be changed in the light of more detailed design.

The effect of such changes must be automatically highlighted to the relevant departments to ensure appropriate modifications to procurment and indeed to work processes take place.

Given that the case for the use of computer systems in shipbuilding can be made, then the introduction of these systems can be of benefit when coupled with the change from a traditional shipbuilding approach to the increasing use of group technology, associated product work breakdown organisation of work and the introduction of mixed disciplines in composite labour groups. This change brings with it problems within the shipyard in being able to physically reorganise the shipyard where appropriate, ensure that the work force understands the new organisation of work and, most importantly, still achieve contract timescales. As any shipyard that has undertaken this type of program clearly understands, the problems retraining personnel and coordinating the introduction of this work organisation are daunting.

Almost unavoidable in this scenario is the introduction of new coding schemes to identify the revised method and sequence of manufacture, assembly and installation. While the actual selection of coding schemes that reflect this requirement is in itself a difficult task, the subsequent method employed to introduce these codes to the work force is of paramount importance. This problem has been overcome in part by the use of computer systems and the discipline they

can bring to the use of coding conventions. The problem is then restricted, to a large extent, to the department who must initially introduce a code or its application for a contract. The computer system is then required to impart this code and associated information in a meaningful manner to subsequent and dependent personnel so that they do not have to understand the implications of a code beyond their use of that code.

It becomes apparent then, that programs for training personnel in the ways of group technology should be coordinated with the definition and introduction of computer systems to assist this process. Additionally the level of management information required to effectively operate these programs can also be identified and addressed at the same time by the system to be introduced.

The criteria outlined above may be used to evaluate the applicability of available packaged systems to the shipbuilding process. The remainder of this document addresses the principal elements of shipbuilding technology with production in mind and also addresses the experiences gained in preparing a computer system package to support the introduction of that technology.

At the outset of the change from traditional to product oriented shipbuilding a package capable of handling the process implicit within shipbuilding was not readily available. Packages that were available and where initial efforts at implementation of these had already been made, proved too rigid in the relationships between design, procurement and production. As a result the effort to modify these systems to the specific needs of shipbuilding and thereafter maintain these systems through the introduction of a revised method of working negated the benefit of the traditional package solutions.

More importantly, any system to be introduced had to be capable of supporting a shipyard's requirement through the transition from traditional to interim product oriented organisation of work. This, in terms of computer systems, means that the system must have a flexible design and provide a rapid development process in terms of database and program modification. While this definition of what a computer system should be is widely considered as an ideal in this case it was considered mandatory. This requirement of a computer system was recognised very early in the overall initiative to support the step by step approach undertaken in the introduction of shipbuilding technology and the varying pace at which individual shipyards or departments could progress in the adoption of new working and organisational practices.

The computing solution to this problem lies in the use of 'fourth generation languages' where the ease of modification of data and the rate of program development most closely meet the criteria established. While the process of determining the content of any proposed system does not change significantly, the productivity of data processing personnel in providing the system once it is defined, is increased considerably. Added to this factor is the ability when using fourth generation languages, to produce and agree within acceptable time frames and costs a prototype version of a system. This initial conversion of a specification into a system that covers the main topics of the system function can be viewed and critiqued by a prospective user. This serves to eliminate many mis-interpretations of the written specification sometimes apparent only during implementation and contributes significantly to the acceptance and use of the system by the work force.

It is when a system has been defined and written and is subsequently being implemented that difficulties traditionally arise. What may have been considered a preferential method has now changed or, as is the case when change of the scale made in converting from traditional to product oriented build, separate functional departments within a shipyard progress at different rates. The timescale for a DP department to react to these changes when using fourth generation languages can be measured in days rather than weeks or even months as has been the case for DP in the past. Thus by using a fourth generation language the ability is present to produce a flexible design and to support a shipyard through the stages of introduction of new work organisation.

For the purposes of this document the following topics are those I see as forming the basis of an integrated system in support of shipbuilding technology.

- Requisitioning
- Purchasing
- Receiving
- Stores Control
- Product Definition
- Product Breakdown
- Work Packaging
- Labour and Material Cost Control
- Invoice Clearance
- Manufacturing Demand
- Marshalling and Issue
- Production Feedback

Planning systems, CAD/CAM systems, finance systems, detail shop scheduling systems are therefore defined as being non-integrated but all of these systems require an interface, in some cases bi-directional, with the production administration systems listed above.

The result is an integrated system that, in summary terms, and identifying the

significant change seen functional area operates as follows:

PRE-CONTRACT AND FUNCTIONAL DESIGN

within the pre-contract and functional design phases the objective is to ensure that the vessel conforms to and will perform the required tasks with consideration to function, payload, space, speed, etc. Typically it involves production of a preliminary hull form, general arrangement drawing and basic operational calculations (see figure 1).

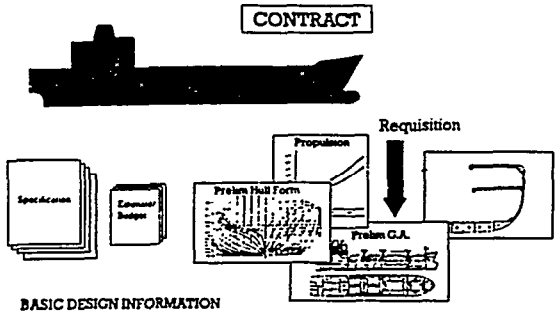


Figure 1. Contract commencement and the means to plan, monitor and control the contract.

At the time of the contract award cost estimates are confirmed and entered to the computer by ship system for material, and by skill or composite groupings for labour.

Prior even to the identification of this information, it may be necessary to identify long lead material items and to commence procurement of these items. This can be achieved by direct entry and use of the requisitioning and procurement facilities within the system.

At contract award a Build Strategy is also confirmed which defines the Company's policy as to how construction will take place. This strategy is applied to the primary construction zones of the vessel which are the first level of work breakdown. Here areas of like difficulty are grouped as a shipyard standard and are addressed independently for material identification at this stage. Typical primary zones would include accommodation areas, machinery spaces, cargo spaces erc.,

Within each primary zone a further definition is made as to purchasing or material ordering zones. This assigns a series of estimated start dates to each section of the primary zone that are keyed to the build strategy and become the initial targets for material availability. (See

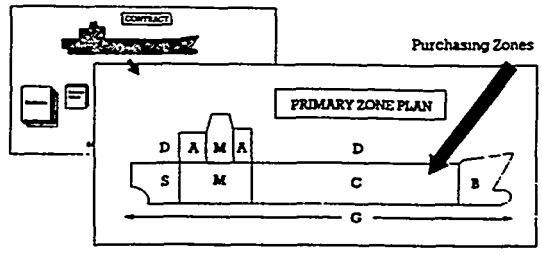


Figure 2. First targets dates targets dates for purchasing

REQUISITIONING

In order to allow for the overlapping of design, procurement and production activities, the ultimate purpose of which is to reduce any delays in the production phase, estimates of the material requirements are made from information available at this stage. These requisitions are submitted to the system and are represented as material lists by system (MIS). When organised correctly, this interface from CAD/CAM systems can provide a significant improvement to the accuracy and timeliness of the transfer of data at a critical stage of a contract. The system, however, must accept that a complete and total interface may not be possible, at least initially, and must provide the means for the submission of data, tailored where appropriate, according to the type of material involved.

PROCUREMENT

The purchasing department is tasked with the responsibility of ensuring that the quantities of material specified in requisition form are obtained at the optimal cost and quality in the time frame designated.

It is the purchasing departments role to open inquiries on this material from preferred (best) suppliers keyed to the delivery dates required. The computer system assists in this process by virtue of a link between the Supplier files and material requisitions which shows the range of products or raw material offered, past performance and lead time for delivery. This information combined with the delivery dates required prompts for action on inquiries, quotations and orders.

Having undertaken this process by using system facilities and having received quotations from suppliers on cost and lead time this information is added to the data available within the system. The purchasing department is now in a position to place orders by the combination of requisition, quotation information and part specification. The data available is

supplemented, where appropriate, by textual information detailing and amplifying the specification of material and quality expectations.

While this represents the simplest form of procurement, to a contract specific requisition, the computer system must also provide for other methods of raising requisitions or the handling of orders.

Stock material, maintained at specified levels, is monitored by the system as to reorder level, economic order quantity and lead time against the demand in production. The system raises requisition and prompts procurement for action to ensure timely replenishment. A sub-system for cyclical inventory must also be available, monitoring on value and frequency of use.

Certain orders will be placed specifically as detailed above but for other material the system provides the ability to group requisitions and/or demand to form a contract wide order. Within this facility options are utilised to release partial orders of the total requirement keyed to the timing and use of the material at a selected level within a single contract or across all contracts currently in build.

The most important aspect of this part of the system must be its capability to recognise any change in the quantities associated with requisitions or by production demand as it is detailed and specified in the product work breakdown of interim products. When these changes or discrepancies are identified then the system prompts the purchasing department to respond to the change thereby maximising the possibility of full material availability to production departments.

TRANSITIONAL AND DETAIL DESIGN

Concurrent with the procurement inquiry and quotation process the transition from the initial system oriented view of the vessel to a product oriented identification of work is being defined. This entails the identification within each primary zone of units or blocks and major outfit modules. The required sequence of the erection and installation of these entities will be determined by the use of planning systems. Several iterations of the contract plan may be produced by these systems before an agreed plan produces an interface to the production administration system identifying the units of the build process and the planned start and end dates of each. This interface will be bi-directional as completions of work, at the level specified by the shipyard, will be communicated from the production administration systems to update the contract plan in the contract managment planning system.

In turn, these units are submitted to a process analysis and detail design stage where components of a unit are identified and the availability of the unit for work or access (known as a stage) is determined (see figure **3).**

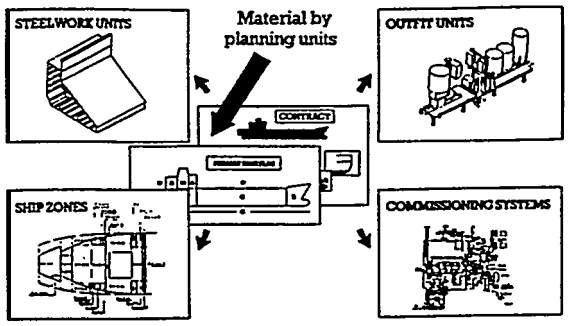


Figure 3. Material identification in a product oriented breakdown.

The computer system, as part of the introduction of this work breakdown, provides a number of options to enable this specification of material to be made. It has been the experience in UK shipyards that it is very difficult to move to early work package definition in one step. Accordingly the system recognises this difficulty and provides facilities to allow identification of material either at unit or block level, stage and work package. Additionally all subsequent material handling also recognises this interim stage of development and provides a corresponding level of facilities within each functional area of the system. Finally, discreet packages of work are identified which when performed in the desired sequence will produce the necessary interim products required for assembly, erection and installation at the appropriate stage in the construction of either further interim products or a unit or nodule. Material requirements both for in house manufactured and purchased items are identified during this phase and are assigned to the work package (see figure **4).**

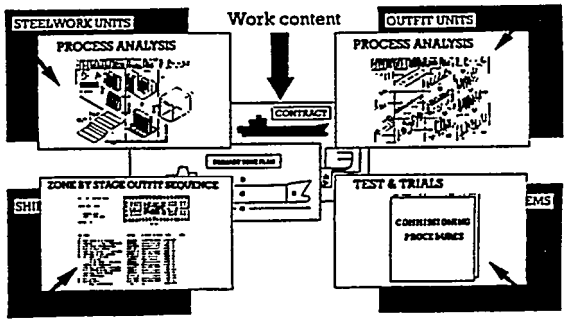


Figure 4. Definition of work content and work packages.

Process analysis to the work package level will also determine the volume of work associated with each work package and will establish, from shipyard performance criteria, the manhour targets (see figure **5).**

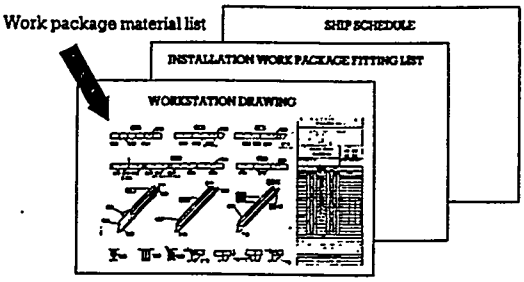


Figure **5.** Detailing of work packages

The work package becomes the focal point for all work within a production environment. Each work package now contains material lists, manhour targets, location of work, start date, etc., From this information the demand for material and labour availability can be determined, the progress of work to timescale can be monitored and a forecast to completion can be calculated (see figure **6).**

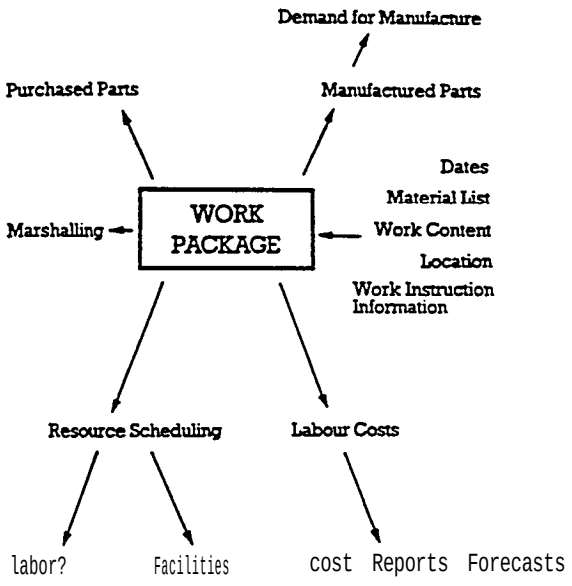


Figure 6. Work package implications.

The computer system fully supports this process and provides a number of options to accommodate varying degrees of skill in attaining this product work breakdown.

Perhaps the most efficient option being a second interface to CAD/CAM computer systems where detailed work instruction drawing complete with material identification is interfaced and related to the work package.

For its own parts and by using the work package as the primary source of data, the system has the capability amongst a number of other facilities to aggregate material required as a result of the detail design process. This data, which defines the specific material requirements of the contract, is compared to those quantities held in the system oriented requisitions being processed by the Purchasing department. Advice is forwarded to the purchasing department in the form of reports or via computer terminals as to where a shortfall has been detected and remedial action is warranted. This facility is also available at unit and stage level to ensure early confirmation of quantities for procurements.

MATERIAL HANDLING

As the process of design and procurement advances and the schedules for production are advance, the flow of materials into the shipyard will commence. It is necessary to receive and inspect these materials for initial acceptance. Subsequently the material must be stored and the location recorded for future use. In turn as the material is required in production it must be withdrawn from its store and palletised and shipped to the production work site.

Again the computer system supports this standard business practice by providing terminal access to data for recording of receipt and inspection and the status accorded the material at that time. Rejections are recorded and reported to the expediting and purchasing departments. the location(s) of the material storage are recorded on the system and the material is recognised as being in inventory for use upon production demand.

Also contained within the system is a method of applying cycle inventory for stock items and those shipyard standards maintained stock items in order to provide a margin of safety stock or inventory. The system provides facilities based upon a classification of usage to ensure that physical inventory is reconciled to that held in the computer files and financial accounts.

In advance of the production demand, routines will provide a pre-marshalling audit of all material required for a work package. These routines will produce reports for use by expediting personnel identifying any deficiencies determined by this process.

In due course and according to scheduled dates, marshalling of material is required to fulfil in house manufacturing or work

package requirements. The system produces reports that identify the material required, including mill mark for steel plates and sections, the location and quantity of the material (including steel stockyard handling routines), the pallet identification, shipping destination and requirement date. The stores personnel marshal and ship the required pallets to the production environment where assigned staff accept and record the receipt of complete work package material lists. This triggers the withdrawal or issue of material from inventory within the system.

The effect of the computer system in this area, when coupled with procurement and product work breakdown data, is a significant improvement in the provision of complete material packages for use by production. Stores personnel have the opportunity to organise material far more effectively than in the somewhat informal methods prevalent in the issuing of material in a traditional build process. This ability is significantly aided by the ready availability of data on the requirements, the storage location and material identification that the computer system provides.

PRODUCT DEMAND

As has been stated earlier, the product breakdown has been organised and scheduled at unit, stage and work package levels in accord with shipyard strategy and key dates of planning determined in the specific build strategy. At the lowest level of work package however, certain items are specified as in house manufactured components. Each of these components has a product structure of the individual piece parts required to form the completed item and each is associated with a process necessary to complete this work. Within each process the operations while not identical may be similar and are knwon as part family operations and are the basis for the application of group technology.

Within the system each of these parts to be manufactured is identified and the components required are also known. The system also relates this manufacturing process to a particular part family, the location of work, sequence of operations and standard lead time.

Based upon the product work breakdown requirement dates, the system collates and groups, based upon a selected horizon, the loading on each manufacturing centre and issues a demand to detailed shop scheduling. Since the grouping of demand is a theoretical load the manufacturing facilities have the ability to group the items into manufacturing work packages that are associated with part family and requirement date. Marshalling instructions for the raw materials, including nesting identification for steel, is issued to stores for their action. At the completion of the production runs, the ouput from these work packages are accepted and recorded by Stores personnel as available inventory and the storage location or holding area is appended. This process is repeated through the build cycle of a vessel and the computer system is used to coordinate the various manufacturing facilities via the production demands.

This process provides a better control mechanism for manufacturing as they are able to gauge the demand upon their facility by the selective use of current and projected manufacturing demand.

COST CONTROL

The preceding sections have dealt primarily with the process required to progressively complete the build of a vessel. Just as important during this process is the monitoring and control of costs associated with the contract.

To this end the computer system provides a number of facilities to aid this task and wherever possible uses activities described earlier to trigger the collection of costs.

In the first instance the contract estimates are entered to the system and are recorded as material and services costs or shipyard labour costs at the level of cost control required by the shipyard.

In the case of material and services costs, the accrual of actual cost against these estimates is generated to the costing portion of the systm by facilities that recognise the trigger action. Thus as purchase orders are issued, as receipts are confirmed, as issues to contract are made and when a suppliers invoice is authorised for payment the system generates transactions to post and record the associated cost value. The net effect being that material costs can be monitored against contract estimates (including post contract award amendments) as committed cost, cost and duration of material inventory, cost of actual material issues and actual cost paid to suppliers.

Similarly the manufacturing process attracts both material and labour cost in the production of in house manufactured items. These costs are also recorded and the system provides several options on the final cost distribution either to a manufacturing centre or as contributary costs to the provision of material to work packages.

The work operations when performed, attract material issued cost and labour cost which is retained as both manhours and in a monetary manner. This latter method also has options which include interfaces to payroll for actual costs or by use of departmental standard rates which can include overhead cost ratios.

As material and labour are incurred by the completion of work packages the system must provide alternate forms of cost reporting. Firstly, based upon contract estimating, the system can apportion costs incurred to a work package across the component systems held within that work package. Alternatively, these costs can be recorded by skill group or trade where contract estimates are made on this basis. Material costs are booked directly to the system to which they apply as the computer ascertains the system identity across the components with in a work package. All of these costs are monitored and controlled against the contract estimates as entered at contract commencement and subsequent amendments to contract when applicable.

The second cost reporting form is by aggregation of work packages to stage and unit level. This is especially important in respect of manhours as work content estimates and thereby target manhours for the contract have been made across all units either at unit level or following detail design to the work packages forming that unit. This aggregation of hours allows for forecasting of manhours to completion and the likely cost and delivery timescale. The forecast is based upon one of a number of options that can be selected by a shipyard. Typical is the use of actual performance to date on work completed against the corresponding targets. This is used to calculate a ratio which is then applied to the remainder of incomplete or future units. The target hours for these future units can be modified by a shipyard to reflect performance or productivity factors organised by labour skill group. These modifying factors can be applied to acknowledge current levels of performance as opposed to the levels attained when the contract commenced. These same manhour recordings are also used to monitor against performance indices by skill group and cost centre.

In this management reporting area, the use of a fourth generation language proves most valuable. While the base data can be defined and maintained in a fairly standard manner, the variations of reporting against this data can vary widely. This is true from shipyard to shipyard and also within a single shipyard dependant upon the stage of implementation of shipbuilding technology and the computer system itself. The data, collected and recorded once, can be viewed from a number of directions and can be reported on according to departmental requirements. The fourth generation language can be used to provide the variation of reports in a timely manner and can be used to modify the same just as quickly as experience or a changing environment dictates.

While the above discussions have centred on contract related costs, it is also important to recognise that the indirect departments should also be able to utilise the same computer system. This ensures that everyone is using the same form of recording and the ability to procure, control and cost all items can be represented from the same source for the entire shipyard.

Suppliers invoices must also be verified against the purchase order and receipt of material. Invoice registration provides this opportunity to match invoices on agreed cost and quantity and posts the actual cost to the cost ledger. The invoice is interfaced to an accounts payable system within the financial systems for appropriate processing and payment.

At points in time determined by a shipyard, the cost ledger is summarised and interface to a general ledger is created and contract costs are entered to the appropriate accounts within that system.

SUMMARY

The previous sections have dealt with the approach to product oriented shipbuilding in a summary form. Correspondingly, the references to the function and facilities within computer systems do not do justice to the full range of transactions, data handling techniques, interfaces, expediting activity and reporting that have been included within the systems.

It is fair to point out that following the initial definition and implementation. the system have been developed in close consultation with shipyards who are applying product oriented techniques. These computer systems are in use in these shipyards and have in fact been instrumental in some cases in the successful adoption of these principles.

As in the case in every industry, one company will vary to a certain extent from another involved in producing very similar products. As stated earlier this is acknowledged by the fact that the systems are developed in a fourth generation language and database manager which enables the system to be customised far more easily than has been the case with traditional computer system packages. A by-product of this ease and rapidity of development allows a shipyard, even with its own personnel, to specify the format and content of reports or computer terminal displays where that provided with in the system does not correspond closely enought to local requirements.

Implementation of systems must also reflect both business considerations and human factors present in a shipyard. The system, while it is primarily a fully integrated shipbuilding solution also must have the flexibility to allow introduction of the functions on a modular basis.

Computer systems using the most current

computer techniques, enhance and facilitate the introduction and continuing development of product oriented shipbuilding together with the administrative tasks required in a business environment.

ACKNOWLEDGEMENTS

The author is grateful to British Shipbuilders for their permission to publish this paper and to his colleagues who have assisted him in its preparation. The views expressed in the paper are however those of the author.